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ABSTRACT

Technological advances and market forces have spawned a microcomputer invasion of the schools, sparking renewed interest and enthusiasm in computers as educational tools. This advent of classroom computers is highly controversial and the question of benefits remains unanswered because of the wide variety of expectations about their educational uses. Poor planning and preparation coupled with scarce equipment causes haphazard, uncoordinated, inequitable implementation. Successful implementation of computer education must be planned thoroughly and flexibly; it must be completely grounded in the theoretical and practical dimensions of change, innovation, and implementation in the educational setting; and it must develop useful, practical evaluative criteria. Any plan of implementation must consider the substantive nature of computer education, the sociocultural aspects of the change, and the implementation process itself. This review of the salient literature on change, implementation, and equity in computer education concludes by suggesting a design procedure to plan for the implementation of computer education in a hypothetical school district. The design is presented as an outline of the questions to be answered, barriers to be overcome, and evaluation of the effectiveness of an educational computing program. A 64-item reference list is provided. (DJR)

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CHANGE, IMPLEMENTATION, EQUITY:
A MODEL DESIGN FOR A COMPUTER EDUCATION PLAN

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TO THE EDUCATIONAL RESOURCES

> Microcomputer innovation is being fueled by a great deal of enthusiasm. The conviction is that the microcomputer is a good thing. Yet no one knows for sure if it is good, how it is good, or what it is good for, in terms of educational outcomes. We need to acquire such knowledge quickly, in order to help guide an innovation which is growing in the absence of research guidance.
>
> Sheingold, Kane, Endreweit, and Billings, 1981, p. 109

Educational computing began in the late 1950s and early 1960s, spurred by much developmental work at Florida State University, Dartmouth, and Stanford. Patrick Suppes and Richard Atkinson of Stanford made pioneering attempts to improve instruction in language and mathematics for children, using the computer as a tool (Walker & Hess, 1984).

The bright promise born in the dawn of the computer age did not necessarily carry through to educational computing, however. The size, cost, and poor quality of instructional materials limited access to these early computers and rendered them ineffective by the mid-60s. School districts could hardly afford well over three hundred thousand dollars for a huge mainframe and its accompanying documentation.

Technological improvements in microprocessors and the action of market forces overcame these early handicaps, so that small, portable, cost-effective

desktop machines came within the reach of a school's budget. The consequent microcomputer invasion of the schools became the vanguard of renewed interest and enthusiasm in computers as educational tools.

Unfortunately the decline in costs and the upgrading of machines did not eliminate all the problems associated with computer education; instead, the expansion of computers has revealed a host of issues hitherto masked by high expenses and bulky equipment. The advent of classroom computers is highly controversial and the question of benefits remains unanswered precisely because of the wide variety of expectations about their educational uses. Originally they fell within the confines of very specific uses; administrators, for instance, used them for pupil attendance projections, test score analysis, grading system development, basic competency results, inventories, financing and budgeting. But the recent influx of microcomputers expanded their application from administrative workhorses and specialized high school computer science courses to additional uses in curriculum development for many students from kindergarten through grade twelve (Becker, 1982; Bitter & Camuse, 1984; Peterson, ed., 1984; Sheingold et al.,

1981; Taylor, ed., 1980; Walker & Hess, 1984).

If anything, this expansion raises the most basic questions: what is the classroom teacher to do with a computer? is the teacher ready for the microcomputer age? Coburn, Kelman, Roberts, Snyder, Watt, and Weiner (1982) pointed out that "the skeptics observe that schools and teachers are no more ready for computers than the machines are ready for them" (p.3). Apparently there are grave deficiencies in both the current generation of computers and teacher training and curriculum development, for even though administrative uses are obvious, classroom applications are not.

The uncertain legacy of early efforts to implement computer education stems from a number of problems, but perhaps the most important general cause of unsuccessful, or uneven implementation, has been the lack of coordinated, flexible planning and preparation. Because teachers, administrators, and students know very little about the microcomputer, the machine or its mystique tends to control the conditions of its use, thereby leaving frustrated educators and students with little to show for their efforts. Furthermore, the diffusion of compact computer hardware, despite its promise to expand access to computing, cannot alone

guarantee such equal access to all; instead, the haphazard implementation born of poor preparation hampers the expansion of educational computing, often restricting its benefits to an advantaged few.

The time has come to end this uncertainty about the value of computers in education; perhaps the most successful experiment in computer education will at first be the one that answers this question regardless of any prior, unrealistic expectations that microcomputers are somehow an unmixed benefit to education. Current conditions will make this difficult, however; the computers are already in the schools, the courseware is being developed, and the public and the communications media demand every day that some form of "computer literacy" take its place alongside the established subject matter in our schools.

This being the case, any successful implementation of computer education must plan thoroughly and flexibly; it must be completely grounded in the theoretical and practical dimensions of change, innovation, and implementation in the educational setting; and it must develop useful, practical evaluative criteria. Therefore, any plan of implemenation must consider the substantive nature of computer education, the

sociocultural aspects of the envisioned change, and the implementation process itself. The biggest obstacle to the successful implementation of a computer instructional design is also the greatest strength of the American way of life: diversity. The wide variability in income, cultural characteristics, and intellectual capability, from individuals to the schoolhouse to the district at large naturally limits the scope and specificity of a plan of implementation.

Recent research supports these basic conclusions about the sources of the present stalemate in educational computing and offers useful suggestions for the future. After exploring the scholarly debate over these issues, this paper will suggest a hypothetical design procedure for an imaginary Wisconsin school district, not as a concrete plan of action, but instead as an outline of the questions to be answered and barriers to be overcome if educational computing is ever to transcend the present stage of frustrated dreams to become a potent, useful force in our children's education.

Although microcomputers make computer technology increasingly available for both home and school use, our knowledge of the educational impact or potential of

computers in our schools lags far behind the awakened public concern with "computer literacy" and "education for the future." Recent research indicates that despite the great potential offered by microcomputer technology, the scarcity of firm evidence on its educational strengths and weaknesses cautions us about the new technology's potential educational impact (Sheingold et al., 1981, p. 4).

The quantitative growth in this field has been enormous, as the demands of parents, industry, and the students themselves have stimulated schools to purchase ever larger numbers of microcomputers (Marrapodi, 1984, p. 57). The nation's schools acquired an estimated 350,000 computers in just the last four years, while Wisconsin schools have 6,525 in place with another 1,103 on order (Campbell, 1984).

This rapid acquisition of new equipment has not necessarily improved education, however. A study completed during the pre-microprocessor age, for instance, warned of the educational system's intrinsic resistance to change and concluded that the rigid, decentralized yet inflexible structure of education stifled any meaningful innovation in pedagogy and curriculum that might have arisen from access to

computers (Oettinger, 1969, in Sheingold et al., 1981, p.3).

Perhaps the reason why we do not know enough about implementing computer curricula in the schools is that this powerful new technology has outpaced teacher training and curriculum development (Becker, 1982; Coburn et al., 1982; Sheingold et al., 1981). As one summary of these developments recently concluded, "changes are taking place so rapidly that it's not at all clear who's in charge....The frightening answer may well be that no one's in charge -- just innovation for its own sake" (Popular Computing, Aug. 1983, in Anderson, Welch, & Harris, 1984). Past experience demonstrates that rushing to place equipment in schools without adequate planning can lead to failure of an innovation (Fullan and Pomfret, 1977; Goodlad & Klein, 1970).

The successful assimilation of computer technology to education must occur along four related dimensions. The first level of assimilation, understanding the process of educational change, must precede the second level, planned implementation of an innovation. But any practical implementation also assumes the third dimension, an understanding of the broad possible

applications of computers to education. (For an extended discussion of this curricular aspect of educational computing, see Knupfer, 1986.) Finally, the successful integration of computers to education requires acceptance by a large, diverse, and at times fragmented constituency; therefore the pressures arising from limited availability and uneven distribution of an innovation must be overcome in favor of more equal access. Certainly any changes should be planned with the culture of schools in mind, especially considerng the stability of the educational system (Romberg & Price, 1981).

CHANGE THEORY

Change theory offers a useful microscope through which we may focus on the school system's response to innovation. The numerous bureaucratic, institutional, and technical barriers against change that are thrown up by the schools clearly illustrate the frustrating gulf between the abstract and the real, and thereby challenge any strategist seeking to channel and implement the new technology in the classroom.

Notar (1980) dissected change into four components: users, implementation, program, and change agency. The

innovation's users should not only understand the change, but they should also be encouraged by the program to understand it. Furthermore, the change program should address both the affective and cognitive domains. Finally, the change agent must take the lead in reducing resistance to change.

Of course change also implies methodology and its effects, including the possible modification of teaching materials or teaching personnel. Fullan (1982) argued that these implications encompass the possible use of new or revised materials and of new teaching methods, and may signal the need to alter traditional beliefs.

There are also theoretical and practical boundaries that define the desirability of change. Thus, relevancy, usability, accuracy, and economy necessarily determine the limits of the possible. Any change must somehow accommodate existing resources with planned activity; relevance precludes radical innovation and can thereby prevent disruption. Proposed changes should temper complexity with easy access and use. The teaching materials should be accurate, purified as much as possible of any biases that might prejudice effective results. Finally, innovation must answer to the administration's typical concern with cost analysis.

These boundaries to change are difficult to define in even the best of all possible worlds; the task becomes more difficult when the hopes fostered by change theory clash with the conservative nature of the educational establishment.

The American public school system's traditional reluctance to change complicates any accommodation to the rapid transformations caused by the introduction of microcomputers. Thus it is very difficult for the average school's staff to plan and adjust to these changes. In a perceptive piece written at the dawn of educational computing's popularity, Seymour Papert (1980) noted the gap between the reality of educational conservatism and the potential for radical change associated with the computer age:

> Today what is offered in the education "market" is largely determined by what is acceptable to a sluggish and conservative system. But this is where the computer presence is in the process of creating an environment for change. Consider the conditions under which a new educational idea can be put into practice today and in the near future. Let us suppose that today I have an idea about how children could learn mathematics more effectively and more

> humanely. And let us suppose that I have been able to persuade a million people that the idea is a good one. For many products such a potential market would guarantee success. Yet in the world of education today this would have little clout: A million people across the nation would still mean a minority in every town's school system, so there might be no effective channel for the million voices to be expressed. Thus, not only do good education ideas sit on shelves, but the process is itself stymied. (pp. 36-37).

Thus in Papert's eyes a scattered and decentralized school system prevents innovation.

But in the face of market forces some barriers to change have fallen away. The decline in computer prices eases equipment acquisition by schools and communities previously hampered by strict budgets and cultural handicaps. As Papert (1980) observed, "space-age objects, in the form of small computers, will cross these cultural barriers to enter the private worlds of children everywhere" (p.4). The computer's penetration of the classroom then shifts our attention from simple acquisition to the problem of proper implementation of these machines within the educational setting and thereby

reveals the real obstacles -- bureaucratic, institutional, and technical -- to successful change (Notar, 1980).

Habits firmly ingrained within the educational bureaucracy may interfere with innovation. For instance, two of the crucial determinants of the educational setting, teachers and administrators, do not cooperate sufficiently to smooth the process of educational change. Administrators often confine teachers to an instructional role that precludes the staff's partcipation in important stages of the change process and assures the adminstration's dominance in planning the proposed change. As leaders, principals are especially crucial to successful change (Lipham, 1979; Jackson, 1978; Weldy, 1979). Unfortunately the administrators' poor understanding of both the innovation itself and their position in the change process may lead to insecurity and a consequent reluctance to act that could doom an innovation in its infancy.

Because many administrators do not appreciate their position as agents of change, they fail to facilitate the staff's adjustments to new role behavior, often giving the impression that they expect complex changes to occur automatically and instantaneously. As the administrative

sovereign of this educational domain, the principal must display the will and leadership necessary to shake loose complacent administrators and staff; by clarifying the ends and means of educational changes, the principal facilitates the staff's shift to new work patterns.

A number of recent studies stress the importance of staff/administration cooperation in the process of change. Neiner (1978) argued that shared decision-making, along with adequate inservice training and continuing curriculum development, can bring successful results. Kanter's studies in the private sector (1983) especially emphasize participation as a key to successful change; companies that include employees in their planning not only implement changes successfully but also enjoy the added benefit of a happier workforce. Fullan (1982) added that in addition to assistance from outside agents, "fellow teachers are often the preferred and most influential source of ideas" (p. 46). The lesson from this research is clear: teachers must enter the frequently restricted terrain of planning and implementation of an innovation.

Unfortunately, administrators often avoid such common sense advice and instead bypass teachers when deciding how to place computers in the schools. This

tendency among administrators to go it alone snowballs along with the teachers' unfamiliarity with microcomputers and with sparse integration of the machines into elementary classrooms and curricula to impede beneficial change and reinforce concern about proper implementation (Sheingold et al., 1981).

Over a long time, such fractures in the educational environment create a mosaic of behaviors whose only common theme is an attitude that resists innovation. Such inertia assumes institutional proportions when the leading actors refuse to face facts. Fullan (1982) argued that successful implementation requires more than just good-quality materials and a demonstrated need for innovation. It must overcome simplistic, institutionalized perceptions both of the real difference between current practice and what is proposed, and of the extent and difficulty of change.

Perhaps the most common such institutional barrier to change is the sum total of mutual, yet isolated, misperceptions among the various agents of change. One study, for instance, noted that because "teachers never obtained a clear understanding of the innovation," the likelihood of achievement declined (Gross, Giacquinta, and Bernstein, 1971). Furthermore, the teachers'

reluctance to admit their ignorance amplifies the inertia already created by the administrators' failure to lubricate the process of change.

Technical problems also threaten innovation and expose not only the difficulty of translating general, abstract program values into appropriate behavior, but also the disjuncture of new ideas and old methods (Charters and Pellegrin, 1973). Fullan's research uncovered this:

> Our experience with computers marks one of the most prominent illustrations of "meaning" as the essence of change. Earlier classroom versions were impractical, mystifying, and frightening to teachers and students alike. The newer microcomputers are more practical, accessible, and usable, although some problems remain in relation to how microcomputers will be used in the classroom and what quality of software programs will be available. (1982, p. 61).

Educators who are poorly trained and prepared for innovation often end up using the machines improperly because they refuse to change their instructional methods and instead force computer education into old frameworks (Becker, 1982; Sheingold, et al., 1981). One reason for

this inadequate preparation may be that the various agents of change have only the vaguest grasp of their part in the process (Fullan & Pomfret, 1977).

Whatever the reasons for this may be, the results threaten the innovation. Several studies have demonstrated the impact of this gulf between old and new. Goodlad and Klein et al. (1970) documented this resistance to change and concluded that "the novel features seemed to be blunted in the effort to twist the innovation in familiar conceptual frames or established patterns of schooling" (p. 72). Fullan (1982) subsumed the disjuncture between hope and reality under the twin categories of "false clarity," (the confusion of substantive for superficial understanding), and "painful unclarity," (the distorted impact of an unclear innovation's meaning on the teacher's own view of his or her job conditions). Effective innovation suffers, therefore, when teachers show more concern about their workloads than about the educational goals and benefits of the program (Loucks and Hall, 1979).

Such misplaced emphasis means that instead of being developed by the whole staff, the innovation "undergoes transformation" to fit the established social and political structure of the schools, demonstrating the

close, almost interlocking relationship between institutional and technical barriers to change (House, 1974). An effective strategy for razing these mutually reinforcing walls against innovation must include provisions for the fusion of organizational with individual goals. Thus, mere understanding of the innovation is an insufficient guarantee of successful implementation (Bennis, 1966).

In addition to poor staff preparation other factors on the technical side of educational change can wreck an innovation. Logisitics -- the supply conditions of instructional resources -- requires continuous planning and development to assure both adequate coverage of the school system in particular and of all students in general. If the demand for support materials for an innovation outstrips the supply the resulting shortage hinders procurement and can have real, damaging consequences (Becker, 1982; Gross, et al., 1971; Sheingold et al., 1981; Wisconsin Department of Public Instruction [DPI] Guidelines, 1983). It forces schools to ration the students' computer access, either by restricting exposure to qualified student groups or by allowing all students short bursts of time with the machines (Becker, 1982; Sheingold et al., 1981).

Clearly computer implementation is no exception to the rules governing the accomplishment of any major change within education. At the most personal level, our conservative nature makes change an uncomfortable process requiring a sometimes painful re-evaluation of long-cherished notions about teaching. But the microcomputer offers exciting possibilities precisely because, as Michael Fullan observed, it "allows individual users to work out the problem of meaning in assessing its educational potential" (1982, p. 61). Such flexibility can make the difference between success and failure in innovation.

In summary, change theory provides useful analytical tools, but the educational establishment challenges their effectiveness. The many bureaucratic, institutional, and technical barriers to innovation carry with them a multitude of ingrained behaviors and attitudes that may thwart any attempt at change. The logistics of acquisition and distribution, although eased by a competitive market, can disrupt equal access to an innovation and therefore require continuous planning and foresight.

IMPLEMENTATION

Implementation is change in action. According to Miles (1964) it is the deliberate spreading of novel, specific change in a planned manner. The obvious logic of the relationship between change and implementation may obscure the differences between the two and thereby complicate analysis. But because the final outcome of any attempted innovation depends directly upon proper implementation, the distinctions must be clear between the larger problem of change and the more practical difficulty of implementation.

One way of making this important distinction is to place implementation within the context of the change process. Several researchers have noted this evolutionary process and have determined its components (Hall & Loucks, 1977; Fullan, 1982). Fullan in particular diagrammed these components along a spectrum that includes initiation, implementation, continuation, and outcome. Initiation encompasses the genesis and proposal of an innovation. Implementation embodies the proposal's adoption and use. Continuation involves complete midcourse follow-through by all participants to determine strengths and weaknesses of the

implementation. Finally, the outcome of the change process entails the evaluation of success or failure.

If implementation is to fit neatly into the larger perspective of the change process, then it must be thoroughly yet flexibly planned before it is adopted. Certainly haphazard implementation will guarantee failure, and the microcomputer's much-hailed adaptibility does not immunize it against the application of this general rule. Fullan warned that good intentions alone are insufficient without informed foresight; the value of a proposed change, (that is, "who benefits and who does not?"), must couple with its feasibility if its true potential is to be realized. Only planning can effect the union of the two.

The schools' experience with computers clearly illustrates the havoc wrought by unplanned adoption and implementation. After an initial failure in the 1960s, computers are re-entering the schools in the form of microcomputers that are far more accessable and affordable than earlier models. Unfortunately these advantages allow teachers and administrators to overlook the need for planning in the rush to place the machines, resulting in a widespread bewilderment about the best

possible uses of this exciting new technology. Without firm direction, educational computing programs may very well end up in the junkyard with many other poorly-implemented innovations (House, 1974).

The potential for disaster demands planning that can unite desired outcomes with practical implementation; such planning must occur before the decision to adopt the innovation. A strategy for change should address not only the larger barriers to change discussed above, but also the obstacles to implementation as well. Such a plan must account for the characteristics of the innovation's adopters; it should allow for the innovation's adaptibility to the conditions in which the implementation occurs; and it should sketch out flexible criteria for successful implementation and the consequent outcomes thereof. Properly conceived, comprehensive planning and implementation will help to close the gaps in our current knowledge of the possibilities of computer education.

A plan for successful implementation should pinpoint the innovation's potential adopters, determine their basic characterisitics, and use this knowledge to stimulate thoughtful discussion of the proposed change.

Rogers & Shoemaker (1971, pp. 137-171) identified five distinct categories of adopters. "Innovators" display cosmopolitan, enterprising qualities conducive to the acceptance of change. "Early adopters" command the intellectual attention of their peers and are often considered "the ones to check with" on a particular question. The "early majority" adopters consciously deliberate the issues arising from a proposal, but they rarely lead the group. "Late majority" adopters seriously question any change, but they are susceptible to the arguments of their peers. Finally, "laggards" dwell on past events and therefore subject any proposal to a suspicious scrutiny that may isolate them from others.

Since researchers have documented a definite correlation between the extent of knowledge and the rate of adoption, some of these adopters may be important to the rate and process of implementation (Rogers and Shoemaker, 1971). "Innovators" and "early adopters," for instance, have had some preparation beforehand so that their contributions could be very helpful.

Although all of these character-types reside within the system and deserve inclusion in any discussion of a proposed innovation, some of them are more disposed

toward the possibility of change and therefore should be encouraged to offer suggestions. An example of such a person might be what Sheingold et al. (1981) refer to as a "teacher buff": "Teacher buffs...are not only interested and knowledgeable about microcomputers but play a central role in spreading the innovation. They give a great deal of personal time to teaching and encouraging other teachers, for little or no compensation" (p. 102). Teacher buffs are not "innovators" so much as they are "early adopters," because while the intensity of their interest may make them the persons "to check with" it may also alienate other teachers and preclude an effective leadership role. As Fullan argued, a teacher's receptivity to suggestions coming from peers does not necessarily mean that ideas brought by overly-excited teachers are acceptable.

The phenomenon of the teacher buff illustrates several facets of the implementation problem. Their good intentions are insufficient to ensure success; teachers who are wildly enthusiastic may actually block adoption by virtue of their interest. Yet their knowledge of the subject is valuable and their favorable attitude, if harnessed properly, may help to swing

doubtful faculty and provide needed support during the critical start of an implementation.

The regular teachers, however, and not the teacher buffs, will arbitrate both the way computers are used and the degree of their implementation. Their decisions about instructional materials, their teaching methods, and their beliefs about educational computing lie at the heart of any implementation. Consequently, vague guidelines for implementation and inadequate teacher training and preparation may scuttle the effort to innovate. Already these handicaps are causing many school districts to reconsider their reasons for adopting this innovation.

Researchers are aware of this and urge that as a remedy proposals should not only be practical and relevant to the school setting and its problems, but also properly prepare teachers to make wise use of these resources (Becker, 1982; Lesgold & Reif, 1983; Sheingold et al., 1981). If teachers are not ready to cope with new situations accompanying the computer into the classroom, they may become disenchanted with the innovation. For instance, Coburn et al. (1982) observed that converging pressures of a large group to use a limited number of machines clearly designed for

individual use, plus the high cost of acquiring enough machines can frustrate teachers, students, and administrators. Lesgold & Reif (1983) claimed that more governmental investments would help circumvent these problems and prevent the harmful use of good technologies.

But more money will not necessarily guarantee real, lasting change; in fact, it may encourage educators to mistake a superficial change for what may be little or no change at all. Romberg and Price (1981) argue that any real, or "radical" change necessarily challenges the school's cultural traditions and assumptions about work, new types of knowledge, and professionalism. An ingrained resistance to modifying these assumptions may divert the direction of an implementation as the school rises to defend previous behaviors from possible erosion by innovation.

The conditions under which an innovation is implemented contribute just as much to the nature of the outcome as do the status of staff preparation and the presence of knowledgeable adopters. Such conditions include the classroom organization, the availability of instructional resources, and the more general demands of the school system or district. The competing demands of

a modern educational environment impress upon the innovator the need to adapt instructional media to circumstances.

There is confusion about how microcomputers can be integrated within the traditional classroom structure (Becker, 1982; Sheingold et al., 1981). Classrooms must accommodate groups of students while microcomputers are designed for interactive education on an individual or small group basis. Therefore, the limited numbers of school computers necessitate significant organizational changes so that teachers may adapt their use to their own classroom needs. We know very little about how schools are actually using the machines, even though usage is the core of implementation.

Research has documented the extent to which implementation of computer education is a mutually adaptive process. Unlike fidelity implementation, which refers to the correlation between the intended use and the actual use, mutual adaptation implementation allows the innovation to change during the process of implementation (Fullan & Pomfret, 1977; Miles, 1964; Sheingold et al., 1981). Certainly mutual adaptation must characterize implementation because the uses of computers are still evolving. The most convincing proof

of this comes from a major study by Sheingold et al., (1981). This study of three school districts revealed that schools assimilate computers according to their own goals, needs, and operational patterns. Consistent with the finding that faster adoption occurs when recognized needs are met, (Rogers & Shoemaker, 1971), each of the three districts modified their innovations to suit their system's larger needs.

Romberg & Price's distinction (1981) between "radical" and "ameliorative" changes must be recalled when recognizing the mutually-adaptive nature of implementation. Fast adoption of an innovation may indicate that the school is not making any deep alterations in the comfortable patterns of behavior that have served so well in the past, a warning signal that the satisfaction of existing needs is more important to the adopters than the adequate planning for future changes that a successful implementation demands. The school's current needs are important, but they are also only a component of the larger process of implementation and change.

It is possible to combine these conclusions with broader studies on implementation to outline some of the criteria for real accomplishments in innovation. Rogers

and Shoemaker (1971) identified five such attributes of successful implementation: relative advantage, compatibility, complexity, incremental trial, and observability, all of which suggest some kind of adaptation. Thus relative advantage points up the question of whether the cure, or the proposed change, is actually worse than the disease. Furthermore, proposals must be compatible with the existing social system. The implementation's complexity refers to the perceived degree of ease or difficulty, presumably suggesting the need for flexibility in the latter case. The incremental trial of new ideas eases adoption by allowing for mutual adaptation. Finally, the successfully implemented innovation is plain for everyone to see; the results are clear and the effects as desirable as possible.

Fullan (1982) described four broad influences on implementation, each with its own set of specifics, that approximate strikingly the findings of Rogers and Shoemaker eleven years earlier. The first category, the innovation's characteristics, subsumes under it explicitness, (what, who, when, how), and complexity, (difficulty and degree of change required of the individual responsible for the implementation). The

second influence encompasses the strategies employed in the implementation, which include inservice training, resource support, feedback mechanisms, and participation. The third determinant of successful implementation depends on the characteristics of the adopting unit. Here the adoption process, organizational climate, environmental support, and demographic factors all play a role. Finally, Fullan argued that the characteristics of the "macro sociopolitical units" -- especially design questions, incentive systems, evaluation, and political complexity -- may help determine a successful result. These larger characteristics within the fourth category might be found at any of three levels: the school, the school district, or even outside these to include the county, state, or nation. Apparently Fullan's categories overlap Rogers and Shoemaker's.

Although Fullan (1982) suggested four types of implementation outcomes, his categories beg definition: the actual implementation of a quality program, the lack of such implementation, the actual implementation of a poor program, and the lack of such implementation (see figure 1). Obviously the first and fourth categories are "successes" since we want quality programs. But

FIGURE 1

POSSIBLE OUTCOMES OF THE IMPLEMENTATION PROCESS

I. ACTUAL IMPLEMENTATION OF A QUALITY PROGRAM	II. FAILED IMPLEMENTATION OF A QUALITY PROGRAM
III. ACTUAL IMPLEMENTATION OF A POORLY DEVELOPED PROGRAM	IV. FAILED IMPLEMENTATION OF A POORLY DEVELOPED PROGRAM

ACTUAL IMPLEMENTATION = There has been a real change in practice.
POORLY DEVELOPED PROGRAM = Lacks value or technical quality.

Note: Adapted from The Meaning of Educational Change (p. 14) by M. Fullan, 1982, New York: Teachers College Press

because the potential benefits of educational computing are unclear, what constitutes a "good" or "poor" outcome remains a mystery. The educational value of computer use in the schools is far from being understood (Coburn et al., 1982), so that the determination of strong criteria for successful outcomes has yet to advance beyond Fullan's model.

Because the microcomputer takes on different forms within different contexts, meshing its diverse characteristics with those of the educational environment seems an impossbile task. At each site, the participants in the implementation bring a formidable amount of cultural baggage that could easily influence and alter the direction of the change process. Fullan (1982) recognizes this, in his own blunt fashion:

> There can be no one recipe for change, because unlike ingredients for a cake, people are not standard to begin with, and the damned thing is that they change as you work with them in response to their experiences and their perceptions. (p. 179).

Given this diversity and constant flux, Fullan developed a set of fifteen variables to assess and plan any implementation (refer to figure 2). It is essential

FIGURE 2

FACTORS AFFECTING IMPLEMENTATION

A. Characteristics of the Change
1. Need and relevance of the change
2. Clarity
3. Complexity
4. Quality and practicality of program (materials etc.)

B. Characteristics at the School District Level
5. The history of innovative attempts
6. The adoption process
7. Central administrative support and involvement
8. Staff development (in-service) and participation
9. Time-line and information system (evaluation)
10. Board and community characteristics

C. Characteristics at the School Level
11. The principal
12. Teacher-teacher relations
13. Teacher characteristics and orientations

D. Characteristics External to the Local System
14. Role of government
15. External assistance

Note: From The Meaning of Educational Change (p. 56) by M. Fullan, 1982, New York: Teachers College Press.

to view implementation as an ongoing process in order to avoid the previous error, (e.g. Rogers & Shoemaker, 1971), of imposing a rigid plan without proper follow-through beyond the adoption and implementation stages. Fullan's variables stretch past the characteristics of the change itself to account for peculiarities at the school and district levels plus the external influences that may intrude on an innovation without warning. As we shall see, this outline of factors that affect implementation, if combined with a general model of the implementation procedure, offers real potential to the educator who seeks not only to implement computer education but also to understand the consequences of that implementation.

To summarize, successful implementation requires the development of a plan that accounts for the attitudes of the adopters and for the environment in which implementation occurs. Researchers have documented that the implementation of computers in the classroom in the past has been a mutually adaptive process with unclear, and sometimes disappointing results.

Furthermore, implementation must be understood only within the broader rubric of the educational change

process. Change and its implementation must consider the functions of administrators and teachers, to provide sufficient information and preparation for innovation; thorough planning and overall direction must accompany the entire process of implementation; sufficient resources must be available to support the implementation; and finally, the users themselves, teachers and students, the most important components of implementation, will determine its real outcome.

EQUITY

While the industrial age emphasized memorization of facts, the post-industrial information age requires the ability to select information, reason abstractly, solve problems, and learn independently. For education to meet these new priorities, the 1984 National Commission on Excellence in Education recommended "Five New Basics": Computer Science, English, Math, Science, and Social Studies. The decision to include computer science with the four traditional subject areas assumes that a changing job market fueled by technological innovation requires computer skills (Lautenberg, 1984). Educators must not only forge a consensus about the exact definition of these computer skills, they must

also address the problem of equity in computer education. Equity focuses on who, if present trends continue, will obtain the skills and under what conditions will they do so.

If, as Hade (1982) argues, "the purpose of public school education has long been to teach the skills necessary for one to function productively in society," (in Lacina, 1984, p. 7), then the recent clamor over computer literacy will eventuate in its inclusion among the basic survival skills in our society. As an important transmitter of cultural values and basic information, the school will be forced to integrate computer literacy as a regular part of the curriculum (Lacina, 1984).

But this concern about the content of curriculum must not ignore the consequences of its implementation; one of the more obvious results of poor planning and implementation amidst the furor over computer literacy and "back to basics" has been unequal access to materials and programs in computer education. Possible consequences of early decisions must always inform the entire process of change and implementation if problems like inequity are to be minimized.

Although the definition of computer literacy may determine the extent and nature of public support for computer education, the term itself is difficult to explain. Many leading theorists disagree about both the definition of computer literacy and desirable uses of computers in education. Arthur Luehrmann's (1981) definition of computer literacy as "the ability to do computing" (p. 683) suggests that the degree of the learner's involvement determines the difference between computer awareness and computer literacy. In his view, computer literacy involves direct interaction between the learner and the computer, with the learner mastering wholly new analytic, expressive, and problem-solving skills (Luehrmann, 1981).

Anderson, Klassen, and Johnson (1981) disagreed with this narrow view of computer literacy, arguing that the skill is more comprehensive than mere manipulation of the computer controls. They maintained that computer literacy must promote a broader awareness of possible computer applications and of its function in society.

This debate over definition implies a great deal about the objectives of educational computing which in turn bear directly upon the question of equity. For example, Computer-assisted Instruction (CAI) formats channel

instruction into low-level uses, (drill and practice, tutorial, demonstration, and most game programs), and high-level uses, (simulations, some simulation games, programming, and many applications), so that the type of instructional use affects the quality of computer literacy. If low-level uses encourage rote memorization under the control of the program, and high-level uses promote independent thinking and stimulate curiosity, then the degree of the learner's exposure to these techniques can either stunt or improve computer literacy.

The selection of an instructional use therefore can promote or retard the learner's heuristic, cognitive development, putting a premium on assuring not only equal access to computers for all students, but also on equal access to the different types of educational computing. Equal access and equal opportunity go hand in hand (Alvarado, 1984; Anderson, et al., 1984; Becker, 1982; Edwards, 1984; Lesgold & Reif, 1983; Sheingold et al., 1981).

Equal opportunity for computer education requires proper planning and implementation. The hasty adoption of computers in the schools threatens the innovation's success and places students at a disadvantage relative to those institutions that do plan ahead. One observer

(Alvarado, 1984) claims that computer education already perches on the threshold to disaster:

> It is a sad fact that computer technology has not lived up to its promise in the schools. Too much time and energy has [sic] been spent on strategies to acquire computers for schools. Too little time and energy has [sic] been spent on planning for the optimal and equitable use of this technology for all students. (p. 14).

Several studies show that inequity exists in American computer education, (Anderson, et al., 1984; Becker, 1982; Sheingold et al., 1981), and that problems frequently arise from the moment computer literacy enters the curriculum (Lacinna, 1984; Enochs, 1984). Group teaching requires groups of computers if pressure on the resource is to be avoided. And even though the computer is intrinsically non-discriminatory schools often use it selectively, scheduling access to the advantage of certain populations over others (Schubert & Bakke, 1984).

According to Edwards (1984) quantitative and qualitative inequities exist. Quantitative inequity obtains when either insufficient funds limit the number of available computers or machine reservations restrict

access to special groups of students in advanced math or gifted classes. Qualitative inequity involves intangible attitudes and institutional biases that presumably pose a greater long-term threat to equal access and use. One may suspect the existence of qualitative inequity when more affluent or gifted students learn valuable programming skills while remedial, minority, and disadvantaged students must suffer through a diet of drill and practice work (Becker, 1983).

Courseware, teacher expectations and training, and parental involvement all affect the quality of educational computing. Subtle biases reinforced by white, male, or affluent stereotypes do exist. Possibly state and federal assistance may minimize the impact of these biases by centralizing the current localized efforts at computer education (Edwards, 1984; Lesgold & Reif, 1983).

Several important variables influence the extent of equity in computer education and highlight the various dimensions of this complex subject. Geographic region, socioeconomic status, gender, race, various kinds of handicaps, and special learner groups within the school may help to explain the causes of unequal access to

educational computing (Becker, 1983; Marrapodi, 1984; Sheingold et al., 1971). The various instructional uses of computers can, if improperly implemented, divide communities and groups by creating computer-literate "haves," who are equipped with an effective survival skill, and computer-illiterate "have-nots," who are ill-equipped to cope with the age of computer information systems (Anderson, et al., 1984). There is every indication that the new class of "have-nots" will be the same as previously -- minorities, women, the poor, and the disabled (Edwards, 1984; Lautenberg, 1984; Nathan, 1983; Schubert & Bakke, 1984).

In an extensive study of computers in American schools, Becker (1982) documented major regional discrepancies. He discovered that emphasis on high- and low-level skills, and student access to machines varied by region, while urban and rural schools within geographic regions displayed different types and frequency of use. The number of machines owned by schools varied according to geographic region and the type of school, (private or public elementary).

Although the regional variable may have its damaging effects, it at least is more identifiable and

open to solution than the combined factors, blatant and subtle, which constitute discrimination by gender in computer education. Despite the many important contributions by women to the field of computing, (a women wrote the first computer program, and one hundred women programmers operated the first major computer, for instance, [Graham, 1980; Lockheed & Frakt, 1984]), computer technology is gaining notoriety as a male domain.

A number of powerful variables help to explain sex-based differences in computer education. Social stereotypes infect classroom behaviors and easily transfer into computer education. Gender-identification of "natural" aptitude for computing can lead males to view the task as useful while females view it as a useless, male activity. Moreover, software and computer-related print materials reflect a male bias. Finally, boys who are physically more aggressive may shoulder girls aside from the machines or in more subtle ways intimidate them from using the computer (Marrapodi, 1984).

Traditional social and parental expectations tend to encourage computer activities more for boys than for girls, imbuing a different sense in each about the

accessibility and purpose of computing in the school and the job market. Thus, parents urge sons more than daughters to get involved with computers, say, by purchasing a home model for them, or sending them to a computer camp in the summer and signing them in to a computer club during the school year. This gender disparity increases with age, class placement, and cost of computers (Fisher, 1984; Gilliland, 1984; Miura & Hess, 1984; Schubert & Bakke, 1984).

Gender-based task differentiation among boys' and girls' perceptions of computer uses may stem from these early influences. A study by EQUALS in Computer Technology shows that boys envision themselves using computers for financial or job purposes while girls, if they admit at all the utility of the machines, tend to limit applications to the home (Gilliland, 1984; Marrapodi, 1984).

Although Lockheed & Frakt (1984) noted that the novelty of computer science still does much to minimize sex role stereotyping in the field, they also have admitted a disproportionate increase in male influence. For instance, students and teachers frequently refer to computer components and characters as male, perhaps influenced by advertisements and software packages that

depict computers as male and as designed for males, (Alvarado, 1984; Marrapodi, 1984; Sanders, 1984).

The insensitivity of much computer software, then, can reinforce existing prejudices. Even a presumably unbiased subject-area like a reading program may reward a correct response with the image of a car racing across the screen. In an interesting study of the intrinsic motivational value of computer games, Thomas Malone (1980) found that boys prefer games with shooting or space themes while girls prefer games with a specific task-orientation. Lockheed & Frakt, (1984) found that when given a choice, girls prefer word processing or business/research applications, while boys enjoy the programming activities.

The very nature of advertising and software cover designs amplifies the image of computers as male and for males (Marrapodi, 1984; Sanders, 1984). Teachers should be more selective and more willing to modify when choosing software, in order to redress the current imbalance in girls' computer time (Fisher, 1984; Lockheed & Frakt, 1984).

The dynamics of role behavior reinforce unequal access to the machines. Boys are more aggressive, often pushing girls away from sign-up sheets, reaching over to

push computer keys, or pulling chairs out from under girls who are working at computers (Fisher, 1984; Schubert & Bakke, 1984). In early adolescence, boys often congregate in groups, intimidating the few girls who venture into computer clubs (Fisher, 1984) and thereby demarcating these organizations as exclusive terrain. Lockheed & Frakt (1984) also found this to be true, noting that when there is one computer in a classroom, use is fairly equal, but that when computers are in a central location, "male self-selection and female default [define] the computer center as 'male turf' -- as socially inappropriate for girls as the boys' locker room." (p. 17).

Female reluctance strengthens male advantages in the competitition for computer time. Males rush to sign up for computers while females seek permission to reserve space (Schubert & Bakke, 1984). The few females who take the time to become involved with available microcomputers in schools tend to defer to males when both simultaneously want to use a computer. Furthermore, such avoidance behavior seems more likely when females are "just discovering" boys (Boss, 1982).

The current characteristics of certain subjects may also encourage crippling attitudes toward computers.

For instance, because mathematics, typically a male-dominated field, is the prerequisite for BASIC programming, girls feel threatened and try to avoid learning the language (Anderson, et al., 1984; Fisher, 1984; Gilliland, 1984; Marrapodi, 1984). Marrapodi warns that "in the past, math anxiety has limited career options for too many females. Computerphobia will have an even more devastating effect on our female students" (p. 58). Unnecessary emphasis on math in computer curricula may strengthen this already formidable barrier. Therefore proper structuring of computer classes to stress computer applications or programming in Logo will remove impediments to those with low math skills, (girls, certain ethnocultural groups, slow learners, and the handicapped).

Female disinclination to use computers apparently intensifies with age; although the early grades experience equal use of microcomputers, the onset of puberty brings changes that affect later attitudes toward computers and computer education (Alvarado, 1984). Girls begin to lose interest in math and computers, and spend more time socializing than boys do. The disparity between boys and girls is greater in advanced classes and expensive activities (Miura & Hess,

1984). Perhaps educational computing methods reinforce these changes through class presentations that channel the students into pre-existing gender-specific behaviors.

In addition to special group priorities, geographical disparity, and sex-based variations in access to computer education, socioeconomic status (SES) can influence the quality and nature of this innovation. Persons of higher SES tend to know about innovations first and therefore are more likely to favor early adoption (Goodlad & Klein, 1970). Furthermore, advantaged school districts populated with innovation-conscious, affluent parents, curious students, and a strong faculty will probably try to overcome any budget constraints to introduce computer curricula. Parents who use computers at home or at work usually urge computer literacy programs for their children. The converse of this is also true: poorer, more traditional schools, whose populations may see computer education as more a middle-class recreation than a basic survival skill are least likely to adopt computer curricula. There is growing evidence of a widening gap in school computer access between affluent and disadvantaged as well as between rural and urban

schools (Anderson, et al., 1984; Becker, 1982; Lipkin, 1984; Campbell, 1984; Lautenberg, 1984; Seni, 1984; Sturdivant, 1984; Wong, Uhrmacher, & Siegfried, 1984).

The disparity according to SES threatens to create an educational computing system biased against low-income ethnocultural minorities. Becker (1982) warned that "a new form of segregation is developing separating those who are familiar with and competent to deal with the new technology from those who are not."

Even when computers are available in poorer schools, their use restricts their education value because the school employs them for reinforcement of basic skills and low-level thinking. Affluent schools do the opposite; they provide programming activities designed to promote broad computer literacy and higher-order thought (Tinker, [1983], in Lacina, 1984). In short, as Daniel Watt correctly observed, "affluent students are learning to tell the computer what to do, while less affluent students are learning to do what the computer tells them to do" (Watt, [1982], in Seidel, Anderson, & Hunter, eds., 1982, p. 59). Stone (1984) agrees, arguing that:

> in an economy increasingly dominated by technology, employment and economic opportunity are becoming

dependent on the acquisition of these new skills and this new literacy. A failure to provide equal opportunity of access to computers and to computer education must not be allowed to drive yet another wedge between privileged and poor." (p. 57).

The promotion of this intellectual gap therefore transcends SES and community size, extending to specific groups of students within schools. The lockstep tracking of students according to SES or perceived learning ability strengthens the gap; students who apparently are college-bound, whether wealthy or in gifted classes, learn higher-level skills. Remedial learners, those of low SES, and minority groups, on the other hand, suffer through drill and practice routines that they correctly judge as boring and tedious. Eventually such students may become alienated from computer education altogether (Alvarado, 1984; Anderson et al., 1984; Becker, 1982).

Students with physical handicaps often benefit from small class size and adequate funding for equipment, but like the slow learner they cannot always keep pace with other students and need more computer time. Additionally, some physical impairments make the machines difficult to use. The handicapped student's

needs offer an excellent illustration of the need for mutual adaptation in computer education implementation, for technology must suit these special needs. Various peripherical devices, such as speech and sound synthesizers, braille readers, and large print displays can enhance the handicapped user's computer learning experience (Harvey & Ginther, 1984; Krolick, 1984).

Many researchers advocate increased government funding as a possible solution to the problems of equity and implementation. Logistics and acquisition, plus the budgetary crises afflicting school districts hard-pressed by declining property tax bases and taxpayer furor over educational costs do seem to point in the direction of greater federal investment.

But educators and administrators should plan thoroughly before reaching for the Federal taxpayer's wallet, because increased government involvement may also worsen existing problems. For instance, programs funded for the gifted, remedial, or handicapped learners totally ignore the majority of "average" students whose characteristics do not automatically attract the public's sympathetic attention. Although undoubedtly exceptional students require exceptional attention, improper consideration of the mass of students who wish

access to computer education may threaten the public's current support for widespread literacy programs. The funding problem, then, recalls the most basic issues in equity: who will benefit from computer education, what job skills will be encouraged, and who allocates educational resources to ensure equitable access and use (Anderson et al., 1984; Becker, 1982; Sheingold et al., 1981)?

Any diagnosis of the inequities in current educational computing reads like a catalog of our present social ills. It is important to caution that the desirability of equal access must be tempered by a wise concern for diversity in education. If the microcomputer's strengths are its adaptibility and capability for individualized instruction, and if mutual adaptation to local needs is characteristic of computer implementation, then it is possible that this admittedly neutral piece of equipment may be used to mirror if not reinforce our existing prejudices at the same time that it encourages individual initiative and higher-order thought.

While we debate these difficult questions, the schools continue to struggle with implementing this innovation. Our wildest dreams about ideal computer use

in the schools may easily be dashed by the most basic attitudes and behaviors that, for whatever reasons, differentiate humans from each other. Thus any successful implementation of computer education must plan for these existing inequities, try to ameliorate their excesses, and attempt to bring the value of computer literacy to as wide a constituency as possible.

RECOMMENDATIONS AND CONCLUSIONS

Although the voluminous research on educational change and implementation may at first glance suggest more conflict than consensus among investigators, it seems quite clear that the history of educational computing and the general scholarly attitude about it may be summarized as "forewarned is forearmed." Successful implementation of an innovation requires careful planning based upon an intimate understanding of the site, the participants, and the possible consequences of the proposed implementation. Such knowledge must be used wisely, and the educational consultant unfamiliar with the causes, conduct, and consequences of change within the educational setting faces an uphill struggle fraught with unanticipated and

undesirable outcomes. The inequities resulting from poor implementation should chasten any instructional designer to place within a more realistic perspective unbridled enthusiasm about the educational potential of microcomputers.

The findings we have just examined suggest that proper planning requires strong cooperation among the consultant, administrators, and teachers. No plan should be superimposed without the active participation of all these groups, no matter how theoretically sound or morally desirable it may seem. Research on innovations identifies three main types of diffusion which for the purposes of this discussion will be termed "top-down," "bottom-up," and "social interaction" (Fullan & Pomfret, 1977; Guba, 1968; Havelock, 1969; Loucks & Hall, 1979; Miles, 1964; Rogers & Shoemaker, 1977; Romberg & Price, 1981). In the first type of diffusion, a few central individuals research and develop the plan which is then imposed on the teachers. This method is efficient but it tends to ignore the users' perceptions of their own requirements; teachers, as users, usually reshape the plan to fit their classrooms or do not use it all.

The "bottom-up" approach, on the other hand, allows the teachers to specify problems and generate worthwhile solutions. This method's "goodness of fit" conforms to unique, individual circumstances, but its weaknesses in change and implementation theory do not recommend it for district-wide applications. Most importantly it can lead to scattered, highly variable types and degrees of implementation that easily produce inequities.

"Social interaction" stresses collaborative efforts, focusing on the innovation's path through the social structure of the schools. Although this model does not specify how the implementation process originates, it does consider the roles of the administration and the users throughout the process. Examples of each of these three frameworks may be found in the three case studies by Sheingold et al., (1981).

A combination of these models permits the rejection of their liabilities and the employment of their strengths in the service of a useful, efficient implementation design. Because original research well-grounded in change and implementation theory is necessary, the "top-down" model's stress on a cadre of experts would facilitate this stage of the design process. A team of administrators and curriculum consultants, (internal and external to the

system), can investigate, organize, and distribute appropriate tasks and guide the implementation along its tortuous course. This central unit superintends the original analysis of the system's needs, guides the planning stage, supports the implementation, evaluates and re-designs as needed, and in general acts as the fulcrum of the entire process.

Of course, the users cannot be excluded. Borrowing from the "bottom-up" approach, the designer must call upon teachers throughout the implementation process to assist in identifying needs, providing practical ideas about merging computer education with the daily curriculum, and assessing substantive and social effects. The teachers' input must precede any final plan, since they have to implement it in their classrooms. Furthermore, the teachers' participation ensures that they obtain ownership of the problem requiring attention in the first place. Kanter's conclusions (1984) about employee participation in decisions support this important dimension of implementation. Teachers are more likely to make an honest effort from which they derive personal and professional satisfaction when they contribute directly to decisions that affect their work.

A combined effort by supportive administrators and competent teachers will smooth the implementation process as they bring to bear their respective expertise. Regular communication among these various groups will go a long way toward ensuring an efficient, high-quality program.

The many barriers to change and implementation discussed earlier pose a real obstacle to the application of this combined approach, so that the coordination of disparate, frequently conflicting groups within the educational system depends upon the leadership and knowledge of the external consultant. This difficult, challenging position requires a thorough understanding of change and implementation, plus a strong dose of personal fortitude and skillful diplomacy to overcome the innate resistance to change that pervades any entrenched institution. Ideally, the external consultant's job is easier when assisted by an internal contact already familiar with the district's peculiarities and work rhythms (Fullan, 1982).

The consultant is the ombudsman of the entire process, disseminating new policies, scheduling meetings, helping to arbitrate disputes, overseeing training, and encouraging participation. Specifically,

this activity occurs along three levels: motivation, implementation, and continuation (Miles, 1980). Motivation entails the assessment of needs, the composition of proposals, and the selection of programs. The consultant facilitates implementation through training, demonstrations, identifying resources, and focusing attention upon the entire process. Finally, the consultant isolates important issues of resources and personnel in order to foster continued change.

All of these functions are very important, but perhaps the most crucial contribution the consultant can make stems from a time-perspective based on a strong understanding of the nature of change and implementation. The tenets of change theory and the lessons of implementation's history remind the consultant that successful implementations require time and patience. The consultant must see that the participants understand this, especially at frustrating moments when everything seems to go wrong. Teachers and administrators, therefore, benefit not only from the supportive atmosphere generated by a concerned and active consultant; they also expand their understanding of the district's needs and the amount of time it takes to fulfill them. A skillful consultant imbues in the

participants the global nature of change and implementation.

In addition to the clear delineation of functions outlined above, an understanding of the appropriate questions to ask about the implementation is necessary to a realistic appraisal of the effort. Fullan's fifteen variables, mentioned earlier, come in handy here (refer to figure 2). These variables are more inclusive and specific than those found in other designs; their greatest asset is flexibility -- they allow for midcourse modifications that invariably arise as the participants adapt to the innovation. For instance, a change in administrative personnel could alter the previously supportive environment, or the changing political winds could generate an unexpected increase or cutoff of government funding that may affect immediately the logistics of resource supply. A brief discussion of these variables may be helpful.

The characteristics of the change itself obviously will affect implementation. The participants must understand the change as necessary and educationally valuable -- it must be relevant to their requirements. Furthermore, they must clearly comprehend the substance of the innovation, its academic and social consequences,

and their function within the change process. A clear design conveys a complete understanding of how and what to implement. The difficulty and extent of the proposed change can make the process complex; that is, an ambitious program is probably also a complex one that requires clear presentation and incremental implementation. And even if the proposal seems clear and simple to the designer, insensitivity to the possible threats posed by innovation may lead to confusion and a breakdown of general confidence in the whole idea. Finally, the change should provide sufficient time and resources for adoption; the degree of its quality and practicality is one measure of its success.

To assess the appropriateness and effect of these change variables, the designer must obtain clear information about the characteristics of who and what will be changed -- the school district, the school itself, and the larger political and bureaucratic realm in which both reside. At the district level, some historical spadework on previous innovative attempts may uncover the nature and consequences of other failed implementations. Such a record could have fostered apathy or cynicism about innovation of which the

designer must be aware. Moreover, the district's adoption process may be either opportunistic or of the problem-solving variety; this could affect the planning of the proposal.

The planning stages of the project should avoid direct community and peripheral staff involvement that may bring up frivolous objections based on a groundless fear of new ideas. Instead, the actual plan should be drawn up by a core of teachers, administrators, and consultants who have access to the survey (outlined below). Central administrative support and involvement is crucial to successful or failed implementation outcomes, especially in a large, diverse district with many different backgrounds and demands to serve. In-service staff development and participation, a persistent theme in this study, ensures an honest effort and evaluation. Too often this aspect of implementation is disjointed and incomplete -- it should occur all along the route.

The length of the implementation and the quality of information needed to evaluate will affect the outcome as well. Excessively brief or extended programs may distort realistic expectations about district-wide applications. The implementation must also consider the

attitudes and influence of both the school board and the community it serves. Parents may be more influential than community groups, and if the current clamor over computer literacy is any guide, then the advent of a computer curriculum will spark interest that hitherto was absent from the district's educational affairs.

In some respects, the school itself is a microcosm of the larger district; the behavior and attitudes of its residents directly affect local implementation efforts. One of the best indications of administrative support is the principal's attendance at workshops and inservice training seminars. The principal's leadership can determine the project's fate, especially in the areas of logistics and school work patterns. Because change brings resocialization and interaction is the primary basis for social learning, teacher-teacher relations affect implementation. The consultant's educational experience and knowledge are important here. Recalling the earlier discussion of the importance of meaning in implementation, teacher characteristics obviously affect the users' sense of efficacy, which in turn determines a successful or failed outcome. If the teacher is confident with the innovation, then even difficult students can benefit from the implementation.

Of course the local system is not isolated; it must conform to the practices and philosophies prevailing in the larger political and social climate. This means that the implementation must account for external factors that could impinge upon the process at any time. Are government policies congruent with local needs? Will they interfere with the program? Will the short attention-spans of legislators and state bureaucrats bring a cutoff of funds? Will strident demands for progress before the implementation gets off the ground in turn pressure previously supportive administrators to settle for cosmetic changes instead of lasting ones?

A sample design procedure for a large Wisconsin school district will put the foregoing discussion into a more concrete perspective. For the purposes of illustration, it is assumed that a "large" district possesses the following characteristics: 1.) It has had some exposure, for good or ill, to computers. 2.) The district is calling in a consultant for the usual reason, that the machines arrived before the teachers knew how to use them in the schools. 3.) The size of the district indicates a mixed population with diverse needs and expectations about schools. 4.) The superintendent's decision to act reflects a genuine

desire to improve the situation, and not the imperatives of bureaucratic, political, or personal gain.

This is not an ideal situation. Even if we are given the support of the superintendent, this is no guarantee that the principals, teachers, and students share his inclinations. Thus a diplomatic sensitivity to current job responsibilities within the educational chain of command is absolutely necessary to smooth the path for coming changes.

Initially the implementation process should be distributed over a three year period, with ongoing adjustments. At the conclusion of this period, a final evaluation informed by intermittent evaluations will determine the future of the implementation. Recalling Fullan's four implementation outcomes (figure 1), a decision that the value of the implementation justifies continuation should be followed by re-design based on a reappraisal of the affects of the factors outlined above.

A three year term has a number of advantages. It provides sufficient lead-time to develop resources, appropriate funds, and anticipate any initial roadblocks. The equipment can be added each year as needed and those staff members who receive early

training can help train latecomers, allowing the program to accommodate staff turnover. Since innovations habitually "catch on" elsewhere, those schools implementing in the third year will assimilate faster than those in the first year. This implies an incremental implementation, with the district divided into quarters (or some other suitable fraction), so that the designer can target those schools exhibiting the least resistance for experimentation during the first year, snowballing through the district to the second and third years.

It is vitally important that incremental implementation not be construed by non-participating schools as somehow permanently exclusive. Progress into the implementation stage requires overcoming barriers to change that, difficult enough to handle in an individual school, are multiplied exponentially throughout the district. Although the target schools receive the greatest attention, interested teachers and administrators from other schools should be encouraged to attend orientation meetings, which should be scheduled as conveniently as possible.

A team approach to implementation would be the most productive. Ideally, teachers would team up according

to curricular areas (across two years in high school) or by grade in elementary school. This team structure would facilitate the development of working relationships in which computers could be incorporated into the curriculum. By following the existing, natural work patterns of each school, the change becomes less threatening and the most important problems surface for collective deliberation.

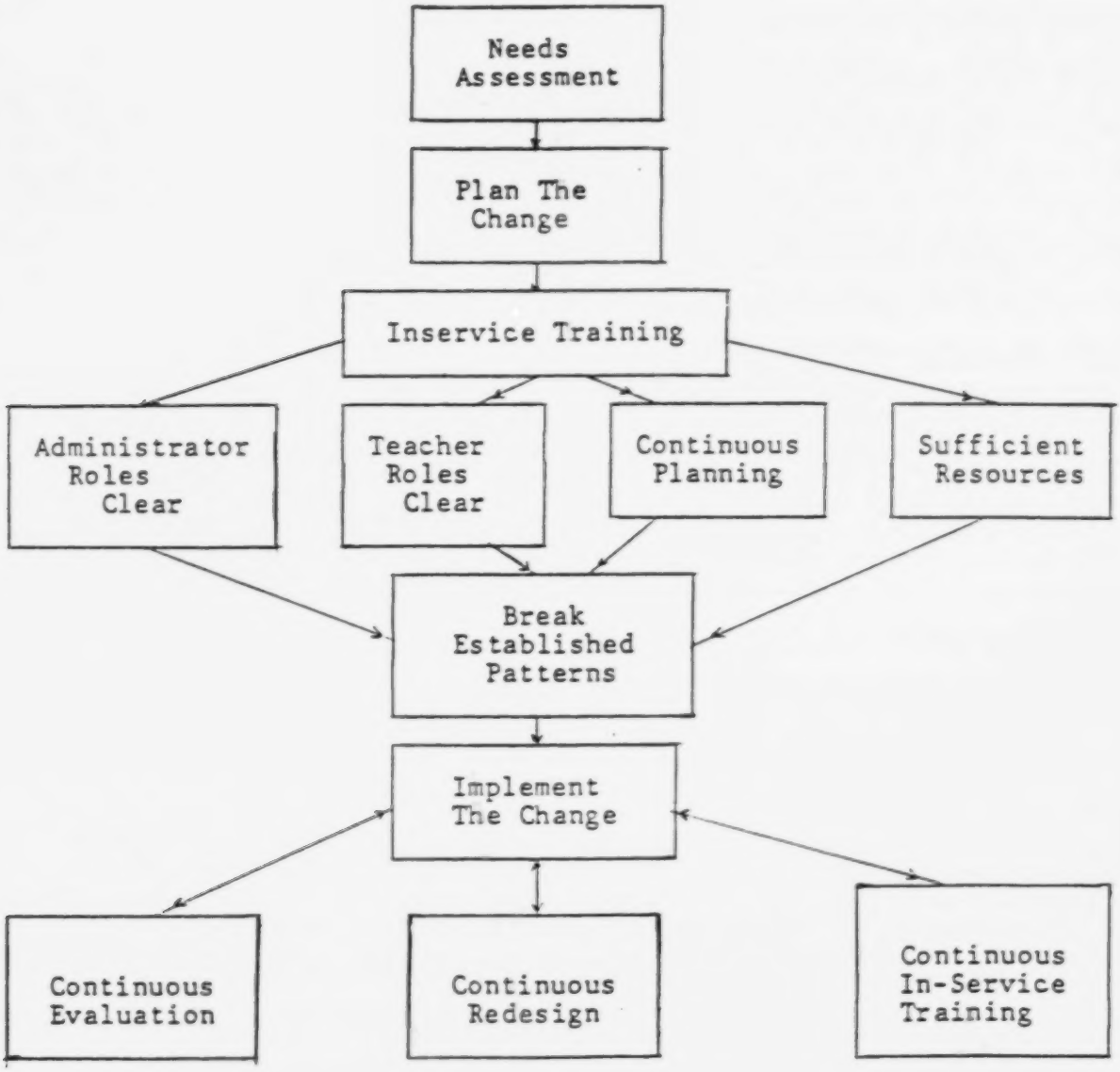
The implementation plan for any district, at any stage, should include the following components (see figure 3): needs assessment; continuous planning; inservice training; sufficient resources; continuous evaluation; and mutual adaptation through re-design. Specifically, this model calls for:

1.) A survey of the participants' needs and environment to determine the scope and content of the change. This includes the composition of a profile of the district and its component schools and neighborhoods. The survey must determine why the district wants computer education in the first place; how the educators and administrators define "computer literacy" and its social and economic uses; and whether its current environment will support implementation.

This last factor is extremely important, because

FIGURE 3

COMPONENTS OF THE IMPLEMENTATION PROCESS



the existing educational and social context directs the method and extent of the proposal. Thus, the survey should find out how amenable the institutions and participants are to innovation. Are some more resistant than others? Is an extended trial period necessary, or is the existing climate such that implementation can be effected relatively quickly, painlessly, and equitably? During this stage, the consultant develops and cultivates internal and external contacts, initially as sources of information and guidance. The survey can identify innovators and teacher buffs who would be useful in composing the planning staff and in drumming up support from their peers. The survey must not be intrusive or abstract; it should be couched in clear, understandable prose, asking realistic questions about the current situation.

2.) A district curriculum committee, including the consultant, specifies goals by grade level.

3.) A deliberate plan of phased-in implementation. If the survey reveals that the proposed change is ambitious for this district, then careful targeting of initial and later implementation sites is required. For instance, one-fourth of the schools join the plan for the first year, another fourth the second year, and the

last half at the three-year mark. This graduated implementation permits the incremental application of resources over time, and helps to prevent waste.

4.) After developing the plan and targeting the schools, the curriculum committee orders the requisite materials.

5.) A cadre of resource teachers and administrators, (and possibly students), trains under the supervision of the consultant to use the machines and become familiar with the overall change process. The principal should receive special attention, to learn supervisory and training skills.

6.) Three months before the onset of implementation (perhaps in the spring before fall implementation), teachers at the target schools receive a brief introduction to the innovation plus guidelines for self-evaluation.

7.) Teachers and principals receive five days of inservice training, alternating every other month through the school year. The other five months would substitute evaluations of software, machine use, classroom management, and curriculum requirements, with a final evaluation in May.

8.) Between training sessions and evaluations, the

consultant and the resource teachers visit classrooms to follow-up, make suggestions and receive criticisms.

9.) The five evaluations are combined with the final evaluation, an overall assessment made, and a decision reached about the future of the program for the next year. If it is to continue, then resource teaching teams assemble to prepare to train the teachers at the next year's target schools.

Because evaluation is critical to a realistic assessment of the value of the program, an elaboration is in order here. The reason for multiple, alternating periods of formal and informal evaluations is clear; past implementation plans have tended to short-circuit because they stop before the evaluation stage (Fullan, 1982; Fullan & Pomfret, 1977; Wang & Lindvall, 1984), and those programs that do evaluate usually limit this to assessments of student achievement (House, 1979). Although a sense of powerlessness accompanies the onset of any new activity, it should not be allowed to breed frustrations and resentments that could doom the project, but instead should find appropriate outlets that harness it to productive uses.

Therefore, the evaluation must cover student achievement, the socio-cultural impact of the innovation

on the school and its population, and the implementation process itself. The central question throughout the change process must be "have those directly responsible for the implementation found personal meaning in the change?" The answer will probably touch on the value of the innovation, both educational and social. Obviously a set of negative answers severely threatens the further implementation of the plan.

The following questions might be suitable for the evaluation of the implementation:

1.) Does it have meaning for the teachers? Do they care?
2.) Does it intrude upon or assist classroom management?
3.) Do test results indicate that students are learning?
4.) Access: do all students have the opportunity to use the computer for equivalent time periods?
5.) Are all students exposed to equivalent high- and low- level computing experience?
6.) Are the computers performing tasks for which they alone are appropriate?

7.) Does the curriculum incorporate computers into complete units over contiguous time blocks for all students to pass before moving on to another subject?

8.) Are teachers including computers into written lesson/unit plans?

9.) How comfortable are teachers with using the machines and with their ability to evaluate software?

10.) Are teachers finding enough quality software to meet educational needs?

11.) Does use of the computer facilitate cooperation among students?

12.) Is the image of computing projected by the teacher compatible with equity? Or are certain groups encouraged to use it, while others (females, handicapped, for instance) are not? Are any adjustments being made for disadvantaged users?

13.) Are teachers sharing ideas with other teachers? If so, does it help? If not, why not?

14.) How involved are parents and/or community groups?

15.) Are teachers really implementing, or is the change superficial?

16.) How supportive, and in what ways, is the principal?

17.) Is there enough equipment, (hardware, software, and peripherals), and is it working properly?

18.) Does the training properly prepare the teachers for the implementation? What are its shortcomings? strengths?

19.) Is the students' time at the computer as productive as time under instruction by traditional methods?

Of course this is an abbreviated list; it may be condensed further or expanded, and the evaluation questions can vary with the time and location of the implementation.

In evaluating the general implementation process, the following questions would be appropriate to ask:

1.) What problems are teachers, administrators, and students encountering?

2.) Is the change continuous, allowing for regular communication and necessary adjustments?

3.) What are the educational results?

4.) What is the effect of this innovation on school life?

5.) In what ways is the computer changing the curriculum and organization of the school, (as opposed to just placing it into the existing curriculum)?

The successful implementation of computer education requires knowledge, patience, and persistence. At every stage, the participants must remember that it has taken many years to develop the existing curricula; if computer education is to join become an integral part of academic life, then its users must be flexible and open to innovation. Finally, the failure of an implementation, no matter how brilliantly conceived, hardly signals the failure of educational computing. We must reiterate that no plan fits all cases; that is the real challenge to any consultant.

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